Spatial Pattern of 2013 Dengue Incidence in South Sulawesi

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Abstract

Epidemic dengue is a major public health problem in Indonesia. This study aimed at establishing a spatial pattern of dengue cases in 24 districts in South Sulawesi during 2013 using a combination of Geoda and ArcGis 9.3 programs. A total number of 4,261 dengue cases occurring in 2013 were used in this study. To assess the spatial distribution of dengue cases, Global Moran's I and Local Moran LISA were applied. Results indicated that the distribution of dengue cases in South Sulawesi analyzed according to month by each district for the year 2013 was spatially random rather than dispersed or clustered. Local Moran's I results showed that Gowa and Maros need to be prioritized in terms of decreasing the number of dengue fever incidences. Sinjai, Bantaeng, East Luwu, Barru, Enrekang, Takalar, Maros and Makassar were potentially vulnerable to the spread of dengue disease from their surrounding areas with great number of DHF cases. North Luwu and Pinrang were potential to make its neighboring districts prone to outbreaks of dengue disease.

Key Words: *Dengue Fever, Spatial Autocorrelation, Global Moran's I, LISA*

1. INTRODUCTION

Epidemic dengue is a major public health problem in several countries including Indonesia [16]. Cases of dengue hemorrhagic fever (DHF) rose from January to June in 2013 in five provinces, that is, Jakarta, Lampung, South Sulawesi, Central Kalimantan and Papua. This is due to erratic weather factors and the awareness of hygienic life begins to decrease [10]. A total number of 4,261 dengue cases occurring in 2013 in South Sulawesi. Considering the high number of dengue cases in South Sulawesi, the research needs to be done related to the disease. Since dengue cases vary from one place to another, the spatial and time components must also be taken into consideration [12]. Spatial-temporal interaction among health events is an important component for epidemiological and public health surveillance [8]. In health research, spatial analysis is used to detect and quantify the patterns of disease distribution that may offer an insight into a disease's epidemiology [12].

In this study spatial autocorrelation was applied to map the spatial distribution of dengue cases in South Sulawesi. The spatial autocorrelation can be used to identify the spatial relationships between regions calculated globally and locally. Moran's I can be regarded as global measures of spatial autocorrelation because one statistic or value is derived for the entire study area, describing the overall spatial relationship of all the areal units. However, there is no reason to believe that any spatial process is homogeneous within the distribution itself. The magnitude of spatial autocorrelation can vary by locations, and thus a distribution or a spatial pattern can be spatially heterogeneous. To describe the spatial heterogeneity of spatial autocorrelation, we have to rely on measures that can detect spatial autocorrelation at a local scale. The Local Indicator of Spatial Association (LISA) is designed for this purpose [6].

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A model for spread of dengue fever disease in South Sulawesi has been studied by some researchers [11,13,14]. However, the studies of the spatial distribution patterns of dengue fever in South Sulawesi by using global and local Moran are not yet thoroughly explored. Hence, in this study we aimed to examine the spatial pattern of DHF disease in South Sulawesi both globally and locally.

2. METHODOLOGY

2.1 STUDY AREA

South Sulawesi Province is located between 0°12'- 8° South Latitude and 116°48'-122°36' East Longitude. The province is bordered by Central Sulawesi and West Sulawesi in the North, the Gulf of Bone and Southeast Sulawesi in the East, Makassar Strait in the West and Flores Sea in the South. Its area is 45764.53 km² which includes 24 districts [9]. The map of South Sulawesi can be seen in Figure 1.

Figure 1. Administrative Map of South Sulawesi

2.2 DATA COLLECTION

Dengue case incidence data were obtained from the Ministry of Health in South Sulawesi. DHF incidences were recorded from January to December in 2013 at the 24 districts.

2.3 SPATIAL AUTOCORRELATION

Spatial autocorrelation means that the attribute values being studied are self-correlated and the correlation is attributable to the geographic ordering of the objects [6]. There are two spatial autocorrelation measurements, that is, Global and Local spatial autocorrelation. Global Moran’s I is the common global spatial autocorrelation. The global Moran's I test statistic was used to assess the presence of significant spatial autocorrelation of dengue incidence from January to December in 2013. Moran's I ranges from -1 to 1: a value close to 0 indicates spatial randomness while a positive value indicates positive spatial autocorrelation, and similarly a negative value indicates a negative spatial autocorrelation [7]

2.3.1 MORAN'S I

Moran's I can be defined simply as $I = \frac{n}{\sum_{i=1}^{n}\sum_{j=1}^{n} W_{ij}} \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} W_{ij}(X_i-\bar{X})(X_j-\bar{X})}{\sum_{i=1}^{n}(X_i-\bar{X})^2}$, where n is the number of cases, X_i and X_j denote the observed value at location i and j, $\bar{X}$ is the average of the x values over the n locations, and W_{ij} is the spatial weight measure [1].

Significance test of Moran's I can be assessed under normal approximation or randomization by making use of a row-standardized weight matrix [5]

Test statistic: $Z(I) = \frac{I-E(I)}{\sqrt{var(I)}}$ where $E(I) = -\frac{1}{n-1}$,

$var(I) = \frac{n^2 S_1 - nS_2 + 3S_0^2}{(n^2-1)S_0^2} - [E(I)]^2$ with

$S_0 = \sum_{i=1}^{n}\sum_{j=1}^{n} W_{ij}$, $S_1 = \frac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{n}(W_{ij} + W_{ji})^2$, $S_2 = \sum_{i=1}^{n}(W_{i.} + W_{.i})^2$; $W_{i.} = \sum_{j=1}^{n} W_{ij}$; $W_{.i} = \sum_{j=1}^{n} W_{ji}$ [1,4,15].

Test decision (right-sided test): $Z(I) > Z_{1-\alpha}$: reject H_0

Statistical significance was tested using randomization based on 999 permutations using GeoDa [2].

2.3.2 SPATIAL PROXIMITY MATRICES

The neighborhood matrix used for the computation of spatial statistics, was based on Queen Contiguity and Euclidean distance. The queen contiguity stated that all the surrounding area units can be identified as neighbors of X as long as they touch each other even at a point. The (*i,j*)th element of a spatial proximity matrix W, denoted w_{ij}, quantifies the spatial dependence between regions i and j, and collectively, the w_{ij} define a neighborhood structure over the entire area. We may want to adjust for the total number of neighbors in each region and employ a *row standardized matrix* or the *stochastic matrix* where we divide each w_{ij} by the sum of neighbor weights for region i giving a matrix W_{std}, where $w_{std,ij} = \frac{w_{ij}}{\sum_{j=1}^{N} w_{ij}}$. If region I has four neighbors, each receives weight ¼ [15].

2.4 LOCAL INDICATORS OF SPATIAL ASSOCIATION (LISA)

While global spatial autocorrelation analysis aims at summarizing the strength of spatial dependencies by a single statistic, LISA focuses on heterogeneity of spatial association over space. Local analysis is based on the Local Moran Statistics, visualized in the form of significance and cluster maps [2]. The LISA statistics and LISA cluster maps were calculated using GeoDa.

Types of local spatial association can be seen in Table 1 as follow:

Table 1: Types of local spatial association

			Spatially lagged geo-referenced variable (Lx)
		High	Low
Geo-referenced	High	Quadrant I: HH	Quadrant IV: HL
variable (X)	Low	Quadrant II: LH	Quadrant III: LL

The four quadrants in Table 1 correspond to the four types of spatial association. The lower left (LL) and upper right (HH) quadrants indicate spatial clustering of similar values: low values (that is, less than the mean) in the lower left and high values in the upper right. The upper left (LH) and lower right (HL) quadrants indicate spatial association of dissimilar values: low values surrounded by high neighboring values for the former and high values surrounded by low values for the latter [3].

3. RESULT AND DISCUSSION

3.1 DESCRIPTIVE ANALYSIS

The dengue case data were recorded at district level from January to December in 2013. Generally, the highest number of dengue cases in the province of South Sulawesi in 2013 was in Bulukumba (612 cases) followed by Bone (603 cases), Pinrang (386 cases), Pangkajene (342 cases), Gowa (311 cases) and Makassar (265 cases). While the lowest number of dengue cases was Sinjai (7 cases), followed by Barru (10 cases). However, there were some districts not infected with dengue disease, that is, Selayar, North Toraja and East Luwu. The highest number of dengue cases in South Sulawesi occurred in January (590 cases), then in February (498 cases), in March (497 cases), in May (450 cases), in June (400 cases), in July (397 cases), and the lowest in December (150 cases).

3.2 SPATIAL AUTOCORRELATION

South Sulawesi has 24 districts, so the size of contiguity matrix is 24 × 24. The contiguity matrix describes the number of neighbors in each district in South Sulawesi. Gowa has the greatest number of neighbors (8), while East Luwu has the least number of neighbors (1) and Selayar does not have neighbor. The values of Global Moran's I and Z-Score computed for a row-standardized spatial weight matrix based on first-order contiguity using ArcGIS can be seen in Table 2 and Figure 2.

Table 2: Moran's I and Z-score using ArcGIS.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Moran's I	-0.19	-0.21	-0.15	-0.21	-0.14	-0.13	-0.08	-0.17	-0.06	-0.08	-0.15	-0.11
Z-score	-1.09	-1.29	-0.86	-1.2	-0.7	-0.66	-0.29	-0.95	-0.14	-0.25	-0.82	-0.55

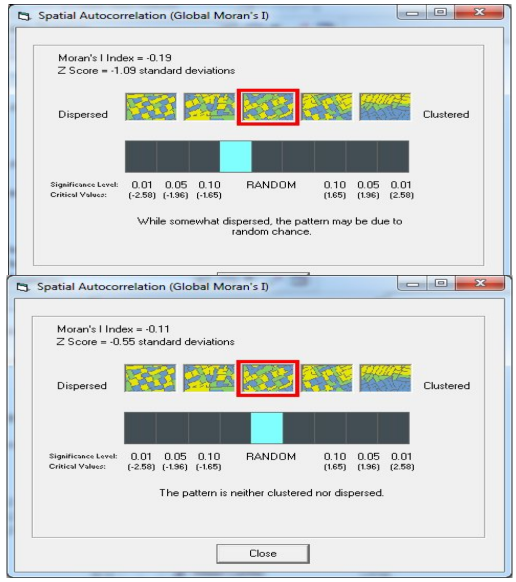

Figure 2: Results of Global Moran's I for dengue cases in January and December in 2013 using ArcGis

Based on Table 2, Z-score values are less than $Z_{1-\alpha} = Z_{0.95} = 1.6449$ with α=0.05 for all months. This indicates that the null hypothesis stating no spatial autocorrelation (spatial randomness) is accepted. Overall, it indicates that there is no relationship between the locations of the observations in terms of disease outbreaks of dengue fever in South Sulawesi.

3.3 LISA CLUSTER MAP AND MORAN SCATTER PLOT

Based on Figure 3 with significant level α=0.05, it has been found that there was only one district (North Toraja) of which LISA index was significant in January. This means that there was a spatial relationship between the district and the surrounding districts. North Toraja was in the Low-Low quadrant. Similarly, in February, Sinjai was the only district having significant LISA index and it was in Low-High quadrant. Further, in March, Bantaeng and Sinjai had significant LISA indices and they were in Low-High quadrant. In April, Gowa, Sinjai, and East Luwu had significant LISA indices. Gowa was in High-High quadrant, while Sinjai and East Luwu were in Low-High quadrant. There were five districts (Maros, North Toraja, Sinjai, Barru and North Luwu) of which LISA indices were significant in May. Maros was in High-High quadrant, North Toraja was in Low-Low quadrant, Sinjai and Barru were in Low-High quadrant, and North Luwu was in High-Low quadrant. In June, Sinjai, Enrekang, and North Luwu had significant LISA indices. Sinjai and Enrekang were in Low-High quadrant, while North Luwu was in High-Low quadrant.

In July, Takalar, Sinjai, and Maros had significant LISA indices and they were in Low-High quadrant. There were two districts (Maros and Sinjai) of which LISA indices were significant in August. Maros was in High-High quadrant, while Sinjai was in Low-High quadrant. In September, Bantaeng and Sinjai had significant LISA indices and they were in Low-High quadrant.

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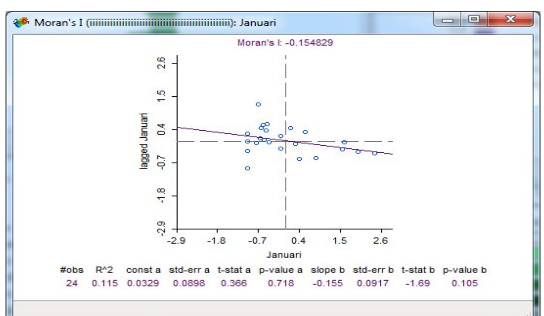
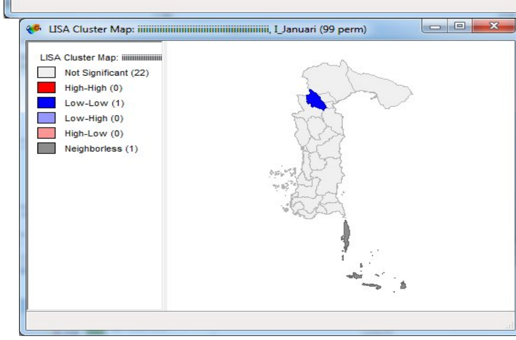
Meanwhile, in October, Sinjai was the only district having significant LISA index which was in Low-High quadrant. There were three districts (Sidenreng Rappang, Sinjai, and Pinrang) of which LISA indices were significant in November. Sidenreng Rappang was in Low-Low quadrant, Sinjai was in Low-High quadrant, while Pinrang was in High-Low quadrant. Finally, in December, Makassar was the only district having significant LISA index and it was in Low-High quadrant.

Gowa was in High-High quadrant in April only, while Maros was in High-High quadrant on May and August. This means that the number of DHF patients in this area was big, and surrounding districts had big number of DHF patients too. However, North Toraja was in Low-Low quadrant in January and May, while Sidenreng Rappang was in Low-Low quadrant in November only. This means that the number of DHF patients in this area was small, and surrounding districts had small number of DHF patients too. Interestingly, Sinjai was in Low-High quadrant consistently from February to November, while Bantaeng was in Low-High quadrant in March and September only. Similarly, East Luwu, Barru, Enrekang, and Makassar were in Low-High quadrant in April, May, Juni, and December respectively. Takalar and Maros were in Low-High quadrant in July only. This means that the number of DHF patients in this area was small but surrounding districts had big number of DHF patients. It can be claimed that Sinjai, Bantaeng, East Luwu, Barru, Enrekang, Takalar, Maros and Makassar were potentially vulnerable to the spread of dengue disease from their surrounding areas. Finally, North Luwu was in High-Low quadrant in May and June, while Pinrang was in High-Low quadrant in November only. North Luwu and Pinrang were potential to make its neighboring districts prone to outbreaks of dengue disease.





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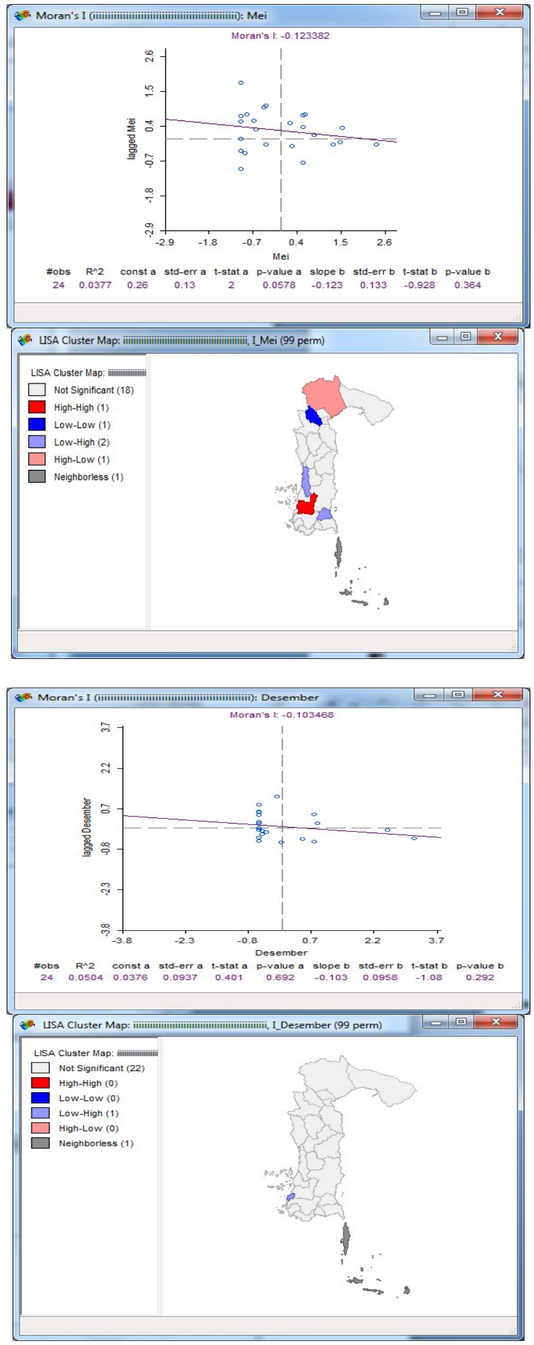

Figure 3: Moran's I and LISA map using GeoDa on January, July and December 2013

4. CONCLUSION

Global Moran's I results indicated that the distribution of dengue cases in South Sulawesi analyzed according to month by each district for the year 2013 was spatially random rather than dispersed or clustered. Local Moran's I results showed that Gowa and Maros need to be prioritized in terms of decreasing the number of dengue fever incidences. Sinjai, Bantaeng, East Luwu, Barru, Enrekang, Takalar, Maros, and Makassar were potentially vulnerable to the spread of dengue disease from their surrounding areas with great number of DHF cases. North Luwu and Pinrang were potential to make its neighboring districts prone to outbreaks of dengue disease.

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